Sensible Atoms: A Techno-aesthetic Approach to Representation

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Sensible Atoms:
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Sacha Loeve *

Abstract. This essay argues that nano-images would be best understood with an aesthetical approach rather than with an epistemological critique. For this aim, I propose a 'techno-aesthetical' approach: an enquiry into the way instruments and machines transform the logic of the sensible itself and not just the way by which it *represents* something else. Unlike critical epistemology, which remains self-evidently grounded on a representationalist philosophy, the approach developed here presents the advantage of providing a clear-cut distinction between image-as-representation and other modes of existence of images, such as the one of '*imaginaction*' that I draw from a comparison between far-field and near-field microscopies. Once this regime of imaginaction is distinguished from representation, I focus on nanotechnological percepts and argue that they follow a *transmodal* logic. I then draw the implications of this enquiry in terms of a *new sensible condition* that changes the way we think of non-living objects. Finally, I conclude that if techno-aesthetics dares to posit and articulate sensibility beyond the privileged sphere of subject/object relationships, it simultaneously engages us to consider the political character of our responsibilities towards the design of nano-engineered sensorial spaces.

Keywords. Aesthetics | Baumgarten | Bergson | Deleuze | Nanotechnology | Near-field microscopy | Philosophy of scientific instruments | Techno-aesthetics | Whitehead

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0. Introduction

> We cannot see or feel or hear the single atoms. Our hypotheses with regard to them differ widely from the immediate findings of our gross sense organs and cannot be put to the test of direct inspection. (…) If it were not so, if we were organisms so sensitive that a single atom, or even a few atoms, could make a perceptible impression on our senses—Heavens, what would life be like! To stress one point: an organism of that kind would most certainly not be capable of developing the kind of orderly thought which, after passing through a long sequence of earlier stages, ultimately results in forming, among many other ideas, the idea of an atom.
>
> Erwin Schrödinger, *What is life? The Physical Aspect of the Living Cell* ([60]: 8–9)

These days, seeing atoms has become surprisingly common. While atomic landscapes and molecular machines are almost part of our familiar world, this quote from Schrödinger reminds us how challenging it is to *make sense* of this situation.

0.1. Imaging, Imagining and Representing

The troublesome status of nano-images has been witnessed by an intense amount of cross-disciplinary scholarship. Despite the wide diversity of approaches regarding the various meanings of nano-images, the field has mostly been structured by an epistemological critique of these images. Yet this approach has led to privileging one prevalent way of conceiving the relationships between 'imaging' and 'imagining' over others: The less epistemic credit is given to 'imaging' (as referring to the production of images *from* nanotechnology as a milieu of instrumentation and nanoscale objects), the more the artistic, rhetorical, fictional or ideological 'imagining' function of nano-images is emphasized—and vice-versa. Either the alleged cognitive function of nano-images is undermined in favour of their imaginative function; or the evocative power of these images is submitted to an epistemological critique, denouncing the strategies of make-believe that play on likeness with common perception. Critical epistemology leads to the conclusion that a scanning tunneling microscope (STM) image does not really represent what it pretends to represent. It should therefore be considered as a 'heuristic imagining' or as an 'extended metaphor', but not as an image, that is, 'a genuine and *realistic* representation of what is really there' [54]. With nano-images, everything happens as if, when questioned in the name of truth, they always answer by lying in some way.

The main reason for this puzzling situation is a lack of philosophical questioning over the meaning of *representation* and its becoming in nanotechnological practices. The epistemological critique of nano-images takes for granted that imaging *must* be a means to faithfully represent nature, and that other things should be referred to as 'imaginings' that serve a variety of non-epistemic purposes (promotional, metaphorical, political, ideological, etc.). Actually, the real concern of critical epistemology here is a normative one: it is to *safeguard a certain image of science* and of its *authority* as an activity that *must* remain guided by a theoretical ideal of faithfully representing nature rather than by some

technoscientific stances on redesigning our life-world.[1] The epistemological critic of nano-images is moved by the apprehension than one loses all definition of what a 'good science' is. And the risk, some argue, is one of a general distrust of science by the public.

I do not deny the importance of these matters. But I want to take another direction regarding them: First, claiming that faithful representation of nature is no longer the main epistemic value of imaging practices in nanotechnology does not *ipso facto* disqualify their epistemic value.[2] It may redefine it. Then, acknowledging that faithful representation of nature is no longer the exclusive business of scientific practice does not endorse a disqualification of the notion of representation itself. Rather, it may reinforce the notion of representation on a political level, by allowing our various partnerships with things, objects, materials, machines, and other non-human beings to be politically represented [40].

Moreover, the claim that nano-images do not represent what they pretend to because they cannot possibly show how a nanoscale object is 'really' like, takes for granted the old metaphysical distinction between primary and secondary qualities (i.e.: essential properties of matter as opposed to their macroscopic appearance). There is an ontological background that is implicitly taken as self-evident here. Indeed, it has been stressed that since nanoscale objects and structures are situated below the limit of light diffraction[3], they should be considered as not only *imperceptible*—i.e., unobservable because they are too small or too remote—but as ontologically *invisible* [11]. At the nanoscale, we are thus supposedly entering the realm of 17th century philosophers' primary qualities, the way things are in themselves, independently of us. For 17th century philosophers, the primary qualities such as bulk, figure, number, quantity and motion were meant to be out of reach for the senses, but nevertheless *fully knowable by representation*, unlike the subjective secondary qualities such as taste, smell, colour, taste, odour, sounds, texture, and affective tones. Primary qualities cannot be sensed, and are themselves insensible.[4] They just are as they are. And if they 'look like' something, they thus look like their intellectual representations in the mind, not like their sensible representations, which are ideas

[1] By 'life-world' (*Lebenswelt*), I refer to the Husserlian notion of our ways of being in the world as that which is self-evident, given, and where 'living-together' takes place, prior to any scientific explanation of it.

[2] Tore Birkeland and Roger Strand [9] argue that nano-images are to be considered as real 'images' provided that we understand 'image' in terms of information about some processes and properties that matter in certain contexts rather than in terms of representation. David Goodsell [29] makes a similar argument. As to Lorraine Daston and Peter Galison [18], they claim that the visual culture of nanotech has discarded the ideal of faithful representation in favour of another one, that they call 'right manufacture'. But they do not tell whether or not the ideal of 'right manufacture' entails epistemic values besides engineering and artistic values.

[3] The Rayleigh criterion states that two points can be separated only if the distance between them is greater than half of the wavelength used to resolve their position. The smallest wavelength of the visible light spectrum is 400 nm (violet). The resolution of standard optical microscopy is thus limited to 200 nm.

[4] Note that Lucretius already stated that 'even those things that we perceive to be sensible are produced (…) from insensible elements' ([44]: 860).

of how we feel when affected by things, not of how things are.[5] Of course, the philosophy of Kant has expelled primary qualities out of the knowable realm by discarding any possibility of intellectual intuition. The way things are in themselves can only be thought, but not known: The real stand irremediably far away and the laws of nature are nothing but the laws of phenomenal representation. But now, by depicting nanoscale objects as familiar and 'before-the-hand' objects with recognizable shapes, colours, foreground and background, nanotechnology seems to mark the return of the knowledge of primary qualities… under the form of secondary ones! Undoubtedly, nano-images cause trouble in the categories of representational epistemology. Instead of denying any epistemic robustness to these images in order to 'save' representation, I want to ask if nanotechnological images could better be understood outside the conceptual framework of representation. The approach I propose towards this aim is a techno-aesthetic one.

0.2. Towards a Techno-aesthetic Approach: Assembling Philosophical Tools

What I call 'techno-aesthetics' is an enquiry into the way instruments and machines transform the intrinsic logic of the sensible and not just the way by which the sensible represents something else. It focuses on the functioning and production of images rather than on images considered as fixed givens. Philosophically speaking, techno-aesthetics is a pragmatic and provisory construction that takes as its point of departure Alexander Baumgarten's notion of 'aesthetics' as 'sensible knowledge' revisited with some philosophies that reject the distinction between primary and secondary qualities and which consider the sensible as *being* rather than as a representation: Henri Bergson's conceptualization of 'images in themselves' and 'perception into things' [7], Gilbert Simondon's own techno-aesthetic attempt [62], Gilles Deleuze's 'logic of sensation', and Alfred North Whitehead's non-anthropocentric account of perception as 'prehension', that is, any process by which an entity grasps, excludes, enlists the data, registers the presence of, responds to, or is affected by, another entity [69].

The outmoded and now quite unusual sense of 'aesthetics' I chose to draw upon corresponds to the meaning of the term when coined by Baumgarten from the Greek *αίσθησις* ('*aisthesis*', sensation): 'the science of how something is to be cognized sensitively' ([4]: §115), or 'the art of thinking analogous to reason (…), the science of sensual cognition' ([5]: §1). Somewhere in the midst between Leibniz's and Wolff's rationalism and the nascent romanticism, Baumgarten's aesthetics intended in the first place to be a general theory of *sensible knowledge* and, *thereafter*, a set of considerations on fine arts [33].

Against Kant's twofold reduction of aesthetics to 1) passive receptivity furnishing its materials to intellectual knowledge (in the *Critique of Pure Reason*) and 2) contemplation of a disinterested subject (in the *Critique of Judgment*),[6] it is

[5] This was Locke's point: only ideas of primary qualities are true resemblances; ideas of secondary ones are not. Ideas of primary qualities resemble the real qualities in the bodies, whereas ideas of the secondary ones are only modifications of the primary qualities with regard to our own complexion ([42]: VIII §§ 9–21).

[6] Baumgarten's attempt was indeed promptly dismissed by Kant as 'the disappointed hope (…) of subjecting the criticism of the beautiful to principles or reason, and so of elevating its rules to a

another 'romantic rationalist', Deleuze, who once noticed how 'It is strange that aesthetics (as the science of the sensible) could be founded on what can be represented in the sensible', since for him, 'Aesthetics (…) truly becomes an apodictic discipline, only when we apprehend directly in the sensible that which can only be sensed, the very being *of* the sensible' ([20]: 56–57). Though Deleuze did not even mention his name, Baumgarten awarded to the sensible an entire logic of its own, a logic '*of* the sensible'—and not of the 'empirical', since the former, contrary to the latter, is not to be subjected to a transcendental double. To Baumgarten, indeed, *Aesthetica* is not a derivative or a weakened form of intellectual knowledge, but 'logic's younger sister' (Baumgarten [5]: §13): *Aesthetica* has both a genetic relation to *Logica* and a life of 'her' own. While intellectual knowledge proceeds distinctly, sensibility is the faculty of knowing *confusedly*. But confusion does not mean *absence of clarity* (i.e., obscurity). Sensible knowledge has its own kind of clarity: a '*confused clarity*', whose degrees of perfection are not to be situated on the same hierarchical scale as distinct clarity.[7] Artistic productions, then, are held by Baumgarten to constitute affirmations of 'the confused' elevated to its higher degree of clarity, on the scale of values proper to sensible cognition, and nothing like a translation of material things or intelligible ideas in the sensible. Despite the anthropocentric flavour of Baumgarten's metaphysics, it can be stressed that he construes the sensible as being both the subject and object of aesthetics: epistemological, i.e., a way of knowing, and ontological, i.e., that which is known, the '*being* of the sensible', and not the appearance of what is understood as 'what can be represented'.[8]

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science' ([38]: 22n)—a rather harsh dismissal allowing the same Kant to hijack the term 'aesthetic' in order to refer: 1) in the *Critique of Pure Reason*, to that which remains in sensibility (*Sinnlichkeit*) when isolated and abstracted from all knowledge and conceptual representations, that is, the pure a priori form of empiric intuition or receptivity (i.e. Euclidian space and linear time), in which all phenomena are given and then submitted to the jurisdiction of understanding (*Verstand*); 2) in the *Critique of Judgement* [39], to the feelings that constitute judgments of beauty and the sublime, said to be 'aesthetic judgments' as they are grounded neither in one's objective knowledge nor in one's interest for the existence of an object regarding its capacity to satisfy one's needs or interests, but only on the sort of 'superior' and disinterested pleasure (and pain, concerning the sublime) provided by the pure presence of the object as a representation of the subject (and concerning the sublime, by the feeling of its impossible full presence and partial withdrawal from representation).

[7] Leibniz already distinguished between absence of clarity and lack of distinction. At the lowest level are the obscure and subconscious '*petites perceptions*', for which we have no concept and cannot recognize any object. Then, *apperception*, which is clear and conscious, divides itself into confused and distinct. In *clear but confused apperception* the object is associated with a multitude of features that we cannot list separately by recognising distinctive 'marks' (*notae*) allowing the object's properties to be distinguished. Then, *clear and distinct apperceptions*, are in turn *inadequate* (incomplete) or *adequate* (complete), as well as *symbolic* (mediated by artificial signs) or *intuitive*. The *complete and intuitive apperceptions* constitute the intelligence of God. Baumgarten was not so much calling for a rupture with all epistemological hierarchy as he was claiming that *there is more than only one kind of epistemological hierarchy* and that, consequently, the 'clear and confused' kind of cognition is capable of an intrinsic kind of perfection [45].

[8] As Leyla Haferkamp [32] notices, this even makes Baumgarten a compelling predecessor of Deleuze's own transcendental empiricism as a 'logic of sense' aligned on a 'logic of sensation'.

The main interest of Baumgarten's Aesthetica for our enquiry concerning the logic of the nanotechnological sensible lies in the fact that he did not set apart the epistemic—'imaging'—and the aesthetic—'imagining'—, but attempted instead to unite them in a *cognitio sensitiva* that differs from a theory-driven kind of knowledge.

It is Simondon who envisioned the foundation of a techno-aesthetics in a letter to Jacques Derrida [62]. Though fascinating, the letter is mostly an accumulation of examples: From Le Corbusier to electricity, to the Mona Lisa's smile, to the E V12 Jaguar's motor. However, Giovanni Carrozzini [15] has highlighted some salient features of the letter that mark a shift from Simondon's earlier considerations on the aesthetical dimensions of technical objects [61]. The focus of attention is no longer an aesthetic experience *of* technology or an aesthetic discourse *on* technology, but a *cognitio sensitiva* that proceeds *from* and *within* technological schemes, materials, and processes. The late techno-aesthetics of Simondon is thus nothing like a disinterested contemplation of the pure presence of things in a subject maintaining their functionality at respectful distance. 'The techno-aesthetic feeling seems to be a category more primitive than the aesthetic feeling alone where the technical aspect is only being considered from a functionalist angle, which is impoverishing' ([62]: 18–19). Such a feeling ranges over a large spectrum where pure productive technical experience (making things) and pure contemplative experience (praising the presence of something) are only limit-cases. It shows an expanded attention oriented towards intrinsic operations and allures that do not fully appear. A 'technical analysis of *La Joconde*' Simondon writes, would stress the absence of 'the complete chain of the smile' and decode 'the mystery itself of the non-appearance' ([62]: 11). Even if Simondon might have left his techno-aesthetics mostly unfinished, he developed an interesting way to think of images in a course of psychology on '*Imagination and invention*' [63]. To him images have a life of their own and are only in part dependant on the subject. His method is to follow the genesis of images step by step by focusing on the way they 'haunt' subjects or detach themselves and get embodied in objects of art or technology, along chains of transformation including animals' tropisms, anticipations of actions, simulacra, toys, fineries, symbols, machines, etc. He methodically avoids situating image-production's origin in an already constituted subject in relation with an already constituted objective world. He also expresses a strong disagreement with Jean-Paul Sartre's conception of imagination as 'unrealization' [58]. Instead, he analyses imagination in the light of invention realizing worldly things.

What will follow is an attempt to characterize nanotechnological images in terms of the intrinsic logic of the sensible they display. Three main lines are investigated: I first argue that understanding the production of nano-images entails shifting from the conceptual and practical space of representation into another one, which I call '*imaginaction*' together with Bernard Stiegler [64].[9] To substantiate this claim, I lean especially on a comparison between far-field and near-field microscopies. Once this regime of imaginaction is distinguished from

[9] See note 15 below.

representation, I then focus on the logic of nanotechnological percepts: I characterize them as being essentially *transmodal*. Finally, I draw the implications of this enquiry in terms of a *new sensible condition* that may reconfigure our relationships with non-living objects.

1. From Representation to Imaginaction

Though it may be right in a certain sense, it is *not enough* to claim that nanotechnologies consist in an instrumentation that renders sensible the insensible. The originality of nanotechnologies is not that they produce representations of the invisible, but that *what they produce are not representations*.

1.1. Regime of Representation

Since the rise of modern science, our world has been populated with visible representations of invisible entities/properties/processes.

Consider, for instance, the principle of inertia: it states that a body perseveres in its motion without being subjected to force. Yet one cannot naturally observe it. Mere empiric observation rather leads one to the adverse theory of *impetus*. Inertia can nonetheless be represented in equations (Newton's first law) and be rendered visible in experiments that 'reconstruct' it with forces of opposite vectors neutralizing each other. To give another example: As Gaston Bachelard explains, on the basis of everyday use and observation, we have long believed that in order to produce light one has to burn something, conflating in that light emission and combustion [1]. Today, we distinguish between the electromagnetic phenomenon 'light' and the chemical reaction 'combustion'. Invisible as it may be, this distinction has yet been rendered utterly visible since Edison invented the light bulb, for it produces light by avoiding a heated resistance to burn.

Representation goes along with a sense of distance that is essential to it. Distance, first of all, in scientific judgment, *critical distance*: a representation is *about something* that is not the representation itself; it cannot be purely equated to the objects it attempts to represent, which cannot be considered as being fully given in the representation. As Wittgenstein limpidly put it, 'objects I can only *name*. Signs represent them. I can only speak *of* them. I cannot *assert* them. A proposition[10] can only say *how* a thing is[11] not *what* it is' ([71]: 3.221). The real that is represented stands far away. It is never perfectly knowable. Only indirectly can it be known, reconstructed in a space of artificial signs, which Alfred Nordmann calls 'artful constructions of immediacy' [50]. Such 'immediacy' is not a feature of the whole representation, but only of its points of contact with the distant real. The virtue of representations is to construct an aboutness-relation that clearly specifies the conditions of an immediate agreement with the mediated and distant reality. A representative picture is 'like a scale applied to reality' ([71]: 2.1512) in which 'only the end points of the graduating lines actually touch the object that is to be measured' ([71]: 2.15121). Termed 'co-ordinations', they 'are

[10] i.e., to Wittgenstein: a 'logical picture' of a 'state of affairs'.
[11] i.e., what 'is the case' or what is not (a fact).

as it were the feelers of its[12] elements with which the picture touches reality' ([71]: 3.1515). And these co-ordinations have nothing to do with resemblance. As Michel Foucault put it, representation is 'the dissociation of the sign and resemblance' ([25]: 70). A defining character of representations is that they require the construction of a scene where natural phenomena are re-enacted and even artificially produced in such a way that *representations are in principle distinguishable from the technical means displayed to construct them*. They *re*-present nature. The scientific explanation is to be inserted in this space between the objective scene of representation and the awareness of its constructive operations. It is because the real stands in the distance and is in principle separable from the instrumentation that allows its objectification that the scientific discourse is able to criticize its own representations in the name of faithfulness to the real.

It is important to understand that representation does not necessarily mean 'realism'. For the realist, the representation is 'true' because the sign refers to a state of affairs that is independent from it (as the primary qualities for the early moderns). For the anti-realist (or the empiricist) the representation is 'nothing more than a representation': it cannot be granted the mysterious power to go out of itself[13]; it refers to unobservable entities from which nothing can be ontologically asserted in the end[14]. Note that for the anti-realist, this does not preclude the representation to be convenient, or even true independently of what humans think and do, suffices it that different types of measures are correlated with sufficient predictive power. The point is that such a debate between realists and anti-realists can only take place in the regime of representation.[15]

In the regime of representation, the sensible is cleaved in two: first, it is what 'presents itself', mainly a source of 'epistemological obstacles' which has to be criticized by an appropriate 'psychoanalysis of objective knowledge' [2]. Thereafter, a 'sublimated' sensible is produced in the form of phenomena bringing into light that which never solely presents itself. To Bachelard, the laws of Joule and the light bulb met in the electrified world of Edison, which is akin to a 'second nature' over and above the merely empirical one.

1.2. Apparatuses of Representation

The classical entities/processes/properties of modern science and the nano-objects are *both* invisible *and* rendered visible to humans by means of instrumentation.

[12] i.e., the picture.

[13] Wittgenstein avoided this difficulty by stating that the sign which make up the logical picture is also a fact, and thus, that a relation of co-ordination is nothing more than a relation between two facts.

[14] Bas van Fraasen is, by today, the most distinguished advocate of this tradition [66].

[15] See the interesting attempt of Otávio Bueno. He develops an account of visual evidence as 'the result of some partial mappings between the surface and the image of the sample, so that certain relations among the items in the sample are preserved and represented in the image'. This partial matching is of course *inferred*, and sometimes with the help of 'the theoretical image that was used as a guide in the elaboration of the experiment', which is experienced as *resembling* the experimental image ([13]: 134–135). Bueno argues that 'both realists and empiricists can adopt the account' ([13]: 137). However, he explicitly put that such a debate between realism and empiricism becomes merely a matter of more or less and not a matter of interpretative clash.

Therefore invisibility cannot serve as a distinctive feature of nano-objects here. Moreover, it should be recalled that atoms were already accessible to imaging before the spread of nanotech (Fig. 1).

Accordingly, the problem is not thus that atoms are now instrumentally accessible to imaging and imagining. It is the *way* by which atoms are now rendered sensible and the *concept* of this sensibility that differ. As Karen Barad points out, if 'atoms aren't what they used to be', this is not only because our philosophical conceptions, scientific theories and representations of 'the' atom have changed since Democritus, and then, since the mechanical age of physics, but rather because 'our practices of imaging and imagining and intra-acting with them have changed, and so have we' ([3]: 353–354).

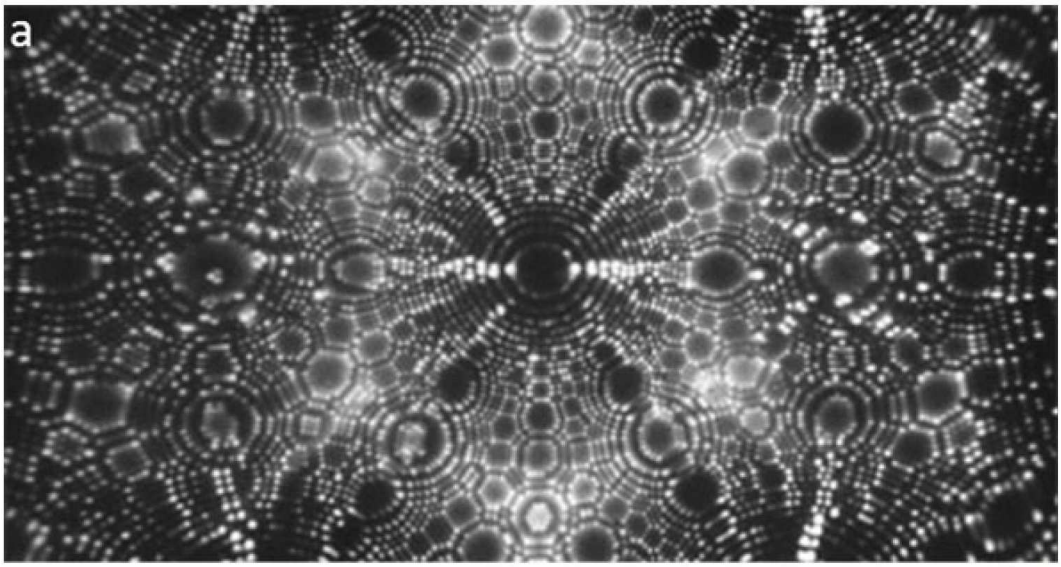
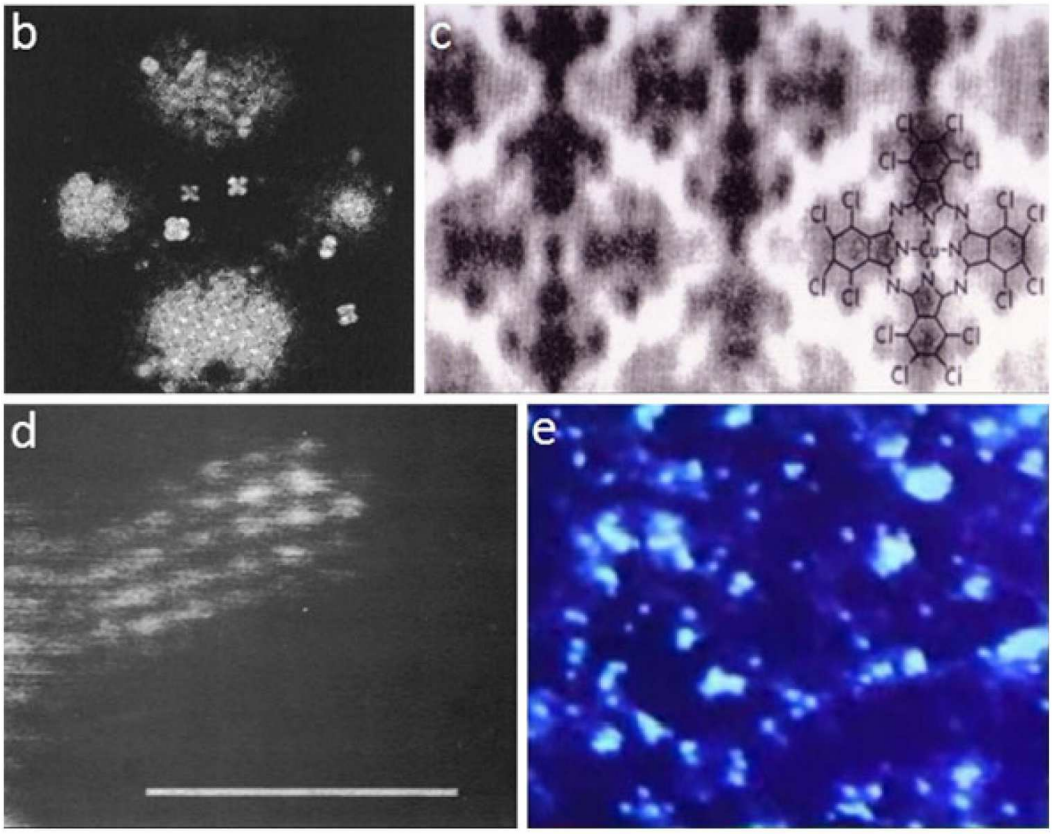


Fig. 1 Imaging atoms and molecules before nanotechnology: **a** Field ion microscope (FIM) image of tungsten atoms on the apex of a tungsten tip. Erwin W. Müller, [48]. The operation runs as follows: A sharp tip is placed under vacuum and cooled down at cryogenic temperatures. An intense positive voltage is applied to the tip. A small amount of inert gas (such as helium or neon) is admitted in the vacuum chamber. The gas atoms move toward the tip and strike it. Being positively charged, the tip atoms tends to take electrons from the gas atoms, leaving them positively ionised. Once positively charged, the gas ions are violently repelled from the tip and accelerated by the electric field along a straight line toward a fluorescent screen. Each spot is the trace of a ion showing 'where it comes from', i.e.: from the immediate vicinity of the atom where it has been ionised. The gas used is called the 'imaging gas'.



b Field emission microscope (FEM) image of copper phthalocyanine molecules adsorbed on a tungsten tip. Erwin W. Müller, [48], from Joachim & Plévert ([37]: 103). The FEM is akin to a FIM without imaging gas: a strong field effect causes electrons to be expelled from the tip and projected on the screen, so as electrons can image some of the fragments deposited on the tip by passing through them. **c** Transmission electron microscope (TEM) image of a copper phthalocyanine crystal. H. Hashimoto, Tokyo University, 1974, from Joachim & Plévert ([37]: 105). **d** Scanning transmission electron microscopy (STEM) of a micro-crystallite of uranium. Scale bar: 20Å ([68]: 4). **e** STEM images of atomic clusters and single atoms (smaller spots) in Brownian motion as shown by Albert V. Crewe (1927–2009) in *The Invisible World* (1979), a National Geographic documentary. Note that A. Crewe claims to having established the visibility of single heavy atoms by STEM since 1970 [17].

Now if we were to meditate about a functioning scheme of any far-field microscope (Fig. 2), we would see that they all bear some family resemblance: a certain radiation (optical, electronic, ionic, X-ray, infrared, etc.) is emitted, focused through a set of lenses (whether optical or magnetic, as in the case of electronic microscopy), interacting with a sample, by which it is transmitted and/or diffracted. Subsequently, a trace of this interaction projects itself in the eye, on a screen, or is recorded by a detector. The result is not necessarily an image that is meant to resemble the object; it can be a curve, a spectrum, etc. In far-field techniques, the notion of distance is somewhat materially present in the instrument. So is the notion of screening. One can find all sorts of filters and grids in far-field microscopes. For instance, Low-energy electron diffraction methods (LEED) display a set of grids blocking the inelastic electrons and letting the

elastically scattered electrons pass through; one obtains a pattern of diffraction on a fluorescent screen. One also uses a lot of mathematical mediations. For instance, the Fourier transform allows matching a diffraction pattern with the determination of the arrangement of atoms predicted by the theory, and thus to co-ordinate experience and theory by an isomorphic relation between their respective points of contact. The apparatus sorts out the data according to the plan of intelligibility chosen to study the phenomenon (a specific range of properties). It performs a test. The sense of the critical distance that defines the epistemic values of representation is also made possible by the distance that the technical apparatus and the mathematical mediations introduce between the representation and the real.

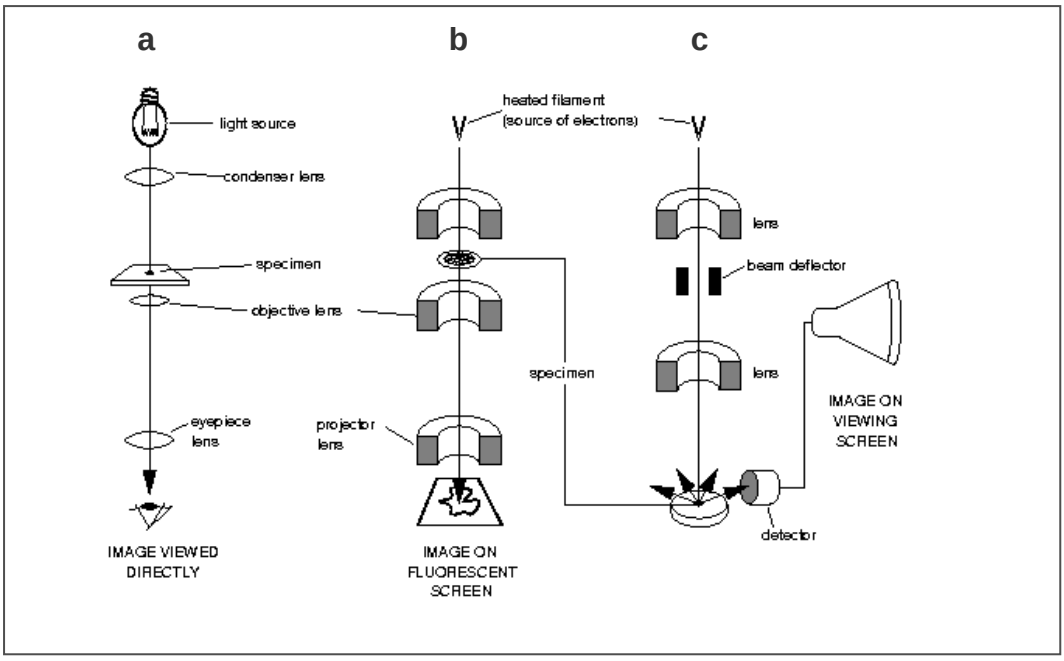


Fig. 2 Schematic diagrams of some far-field microscopes: **a** Visible light microscope. **b** Transmission electron microscope (TEM). **c** Scanning electron microscope (SEM).

1.3. Apparatuses of Imaginaction

How different is this process in near-field microscopy! With the scanning tunneling microscope (STM) and its innumerable avatars, 'imaging' is no more a matter of sending a radiation and gathering a trace from the distance. Instead, it is a dialogue that takes place down at the level of the object and its immediate surroundings—including the atomic-level part of the instrument (the apex of the tip).

Imagine yourself using a STM: you go fetch the information in the near field, approach the object, touch it, feel it, brush it. Scanning at constant height, the STM records how its piezoelectric mechanism reacts, flinches and swishes, under the effect of a tiny short-circuit (or leaking junction) between the sample and the tip, and topographic images are generated from these data. Now, switch from 'imaging mode' (STM as an instrument) to 'manipulating mode' at constant

current (STM as a tool): contact the object, kick it, pulse it, record its electronic 'answer'. Now be creative, and invent other manipulation modes as well (Fig. 3). Or tune the device and run it in a 'semi-imaging' mode: use the STM-xenon atom system as both a tool and instrument that will 'self-image' its own operation (Fig. 4).

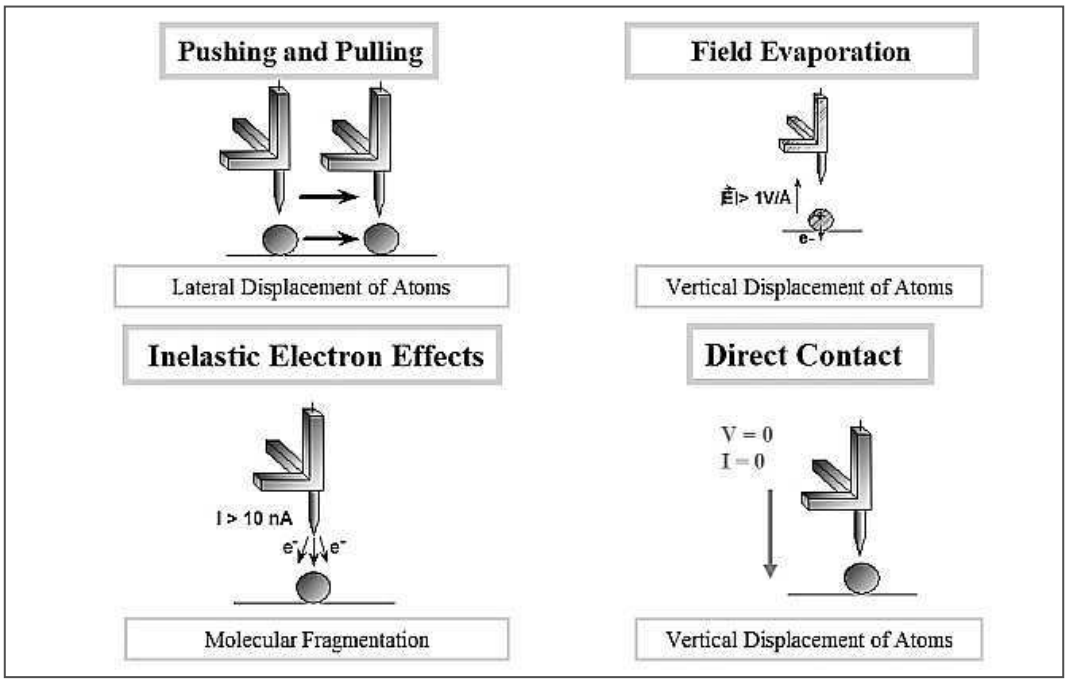


Fig. 3 STM as a tool: Some STM manipulation modes. Courtesy of Andrew Mayne, Laboratoire de Photophysique Moléculaire, CNRS, University of Paris-Sud, Orsay, France.

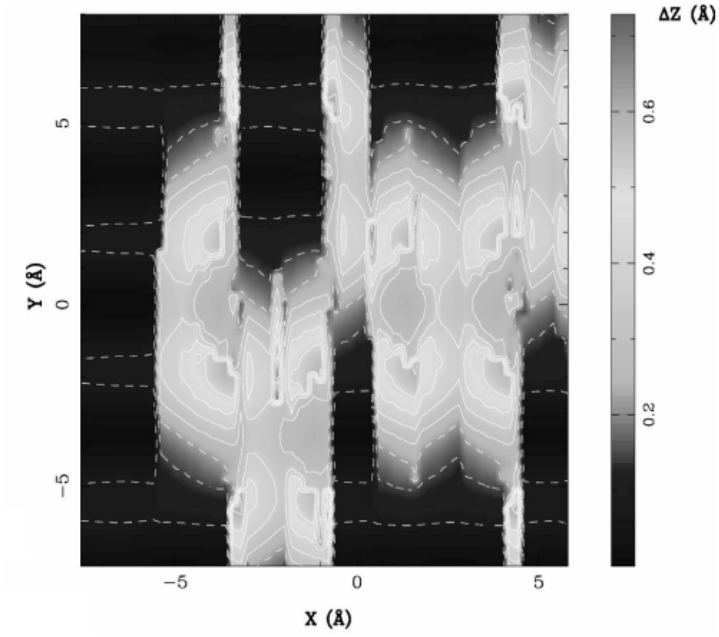


Fig. 4 STM-object system in semi-imaging manipulation mode: Image of an individual xenon atom when pushed from left to right of the frame during scanning along the Y direction. The grey scale ΔZ indicates the variation of the tip-surface distance [10]. Usually, imaging and manipulating with an STM are mutually exclusive modes of operation, with the STM switching back and forth between imaging and manipulating. Here, the parameters hae been chosen so as the STM does both imaging and manipulating in the same time. The STM-xenon atom system 'self-images' its own operation. The distance between representing and modifying has entirely collapsed.

Now use not only the STM as a tool but the object too—for instance, a naphthalene 'Lander' that acts as a movable template to 'mould' the surface (Fig. 5).

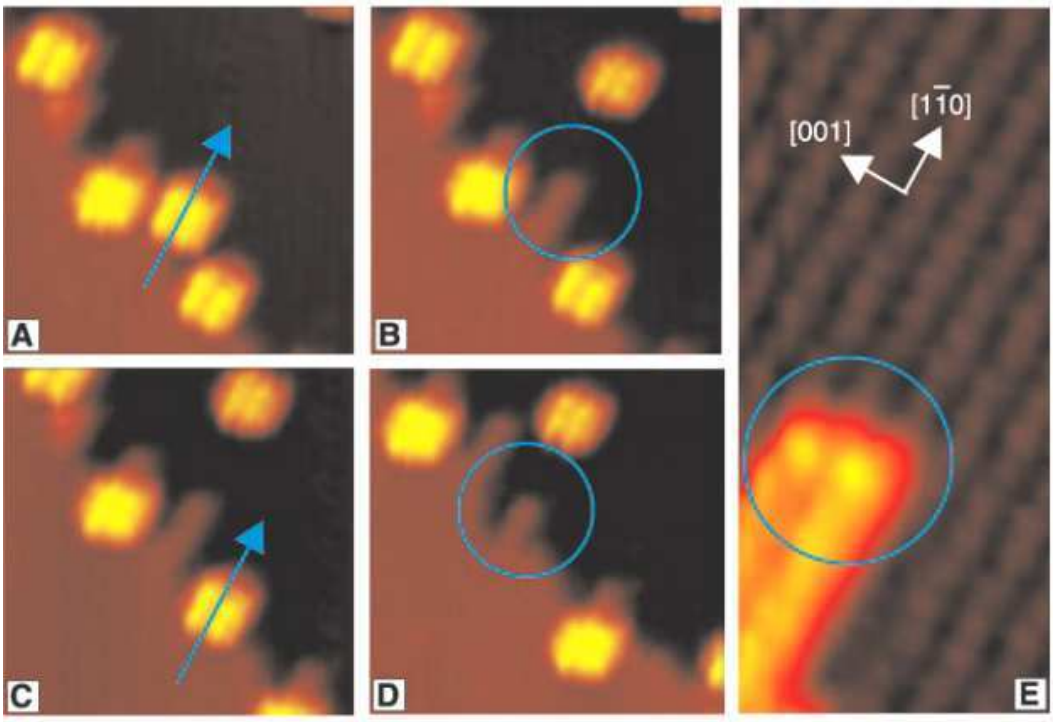


Fig. 5 STM-object system as a tool-tool system: Sequence of naphthalene 'Lander' molecules manipulated from a step edge on a copper-(110) surface [57]. From **a** to **d**, the arrows indicate manipulation direction; the circles mark the modifications induced by the manipulated molecules on the surface step edge (tooth-like structures); **e** uses an image optimization processing to emphasize the fact that the metallic nanostructures created by the STM-Lander system follow one axis in the crystalline orientation of the copper-(110) surface. This phenomenon is explained as follows: During their displacement, the molecular 'Landers' are trapping some copper adatoms lying on the surface under their polyaromatic backbone. Once they cross a step edge, the molecules drop these atoms on the downward terrace along the direction of the copper rows. Researchers speak of 'molecular moulding'.

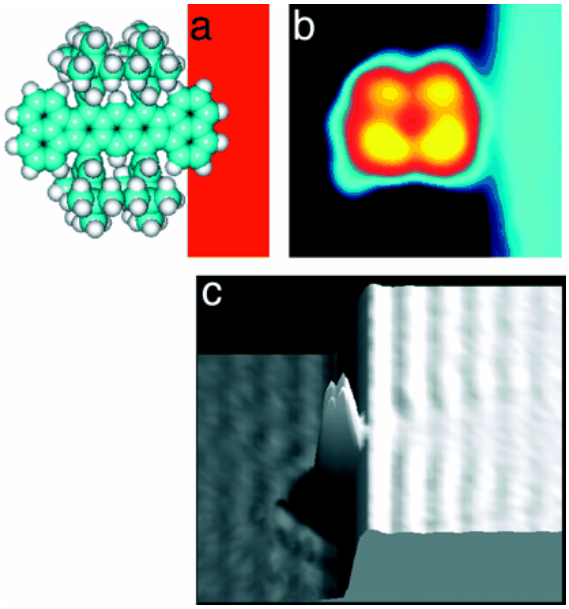


Fig. 6 STM-object system as a tool-instrument system: Here, a similar naphthalene 'Lander' molecule is electrically connected to a step edge. **a** is a schematic view, **b** the experimental STM image, and **c** a simulation of the experiment showing standing wave patterns [47]. This simple system allows measuring something that could never have been measured otherwise: the electronic conductance of a single molecular wire connected to a definite point of an atomic surface. For the narration of this experiment, see Joachim & Plévert ([37]: 59–61). Later on, this experimental system has evolved toward a slightly more sophisticated one: an Ampere-meter at the molecular scale.

Now switch from 'tool-tool' system to 'tool-instrument' system: Place the same molecular 'Lander' in electronic contact with a step edge of the surface and measure the resistance of the molecular wire thereof obtained (Fig. 6). It is as if you were within the sample, on the surface, with the molecule as an Ampere-meter, except that one electrode is at the nanoscale and the other at the macro-scale. Or else, as in the 'manipulated atom image' experiment, trap the cobalt atom under the electrostatic field of the tip to have it part of the imaging system; now, scan the sample and have a glimpse of 'how it feels like' to be a cobalt atom on a copper-(111) surface (Fig. 7): produce unseen (or unheard) physical feelings with 'prehensions of prehensions' [69]; allow the STM to 'prenhend' a cobalt atom so as it will produce an image of how the same cobalt atom 'prehends' the copper surface.

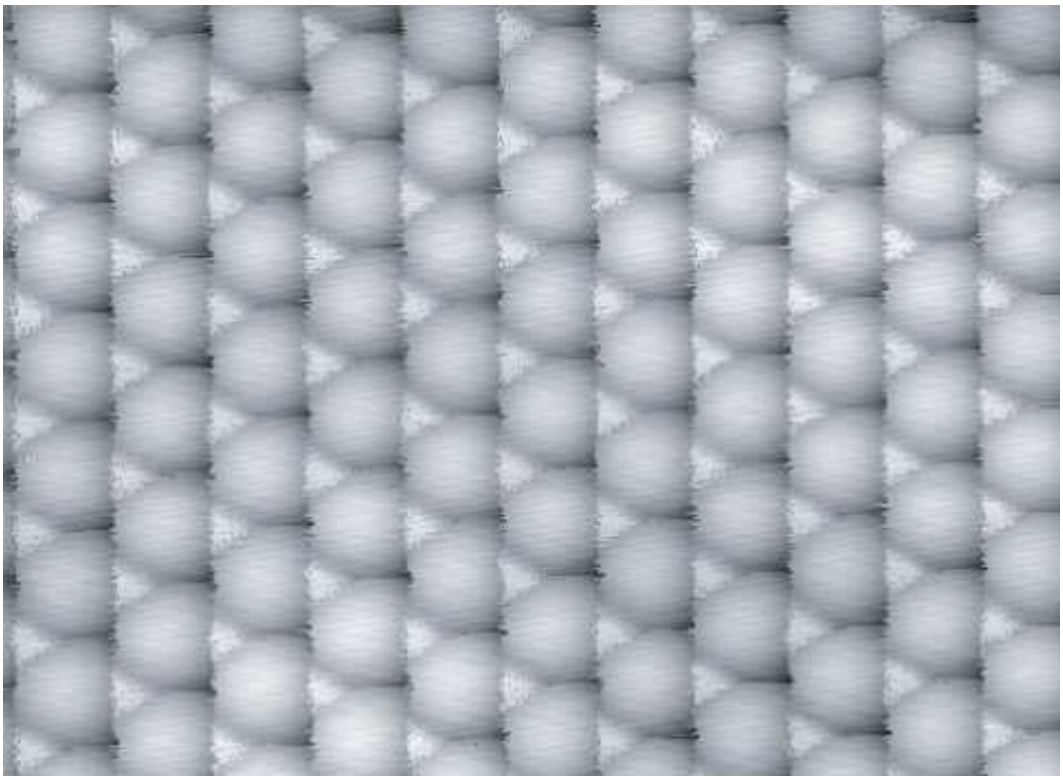


Fig. 7 Feeling like a cobalt atom on a copper-(111) surface: A 'manipulated atom image' [65]. What is shown here are *not* copper atoms. It is the way a single cobalt atom trapped in the electrostatic field of the STM tip explores a copper-(111) surface by random motion: large 'bumps' correspond to the zones explored by the cobalt atom when the tip is situated above a face-centered cubic site of the copper-(111) crystal, small 'triangles', to the zones explored by cobalt when the tip is above a close packed site; dark zones are where the cobalt is not likely to stay (above copper atoms). The overall image is like a cartography of a copper-(111) surface as 'seen' by a cobalt atom—a rather rough cartography; listening to atoms reveals far more tenuous events occurring, as documented in Stroscio and Celotta [65].

Could we not delocalize scientific instruments directly at the nanoscale? This is part of Christian Joachim's dream: 'writing a new textbook in which each of the

old devices is replaced by a single molecule, which becomes simultaneously the experimental apparatus and the subject of experiment' ([37]: 59).

All this illustrates how nanotech plays with the lines between experimental system/technical object, technical object/epistemic thing [56], observing /manipulating, imaging/imagining, instrument/tool, instrument/object, knower/known, and even subject/object, that is, with all the fault-lines defining scientific representation. If they are not dissolved, at least they are each time displaced, short-circuited and reconstructed in specific setups, from which they re-emerge as movable polarities. Even Hacking's notion of 'intervening' [31] would be far too shy here. For not only does the STM interact with the sample (as all microscopes somehow do); nor does it only 'interfere': it 'intra-acts' and 'enacts the between' ([3]: 359).

1.4. Regime of Imaginaction

Constructing a distant picture of nature—representing—is no more the problem. For probe microscopists, 'explaining' the cognitive meaning of the image means accounting for the tightest interaction between the image and the object. As Gimzewski relates, 'traditional scientists shunned this method because its intimacy was seen as a violation of objectivity and distance, a gospel of 19th-century science and epistemology' ([26]:260). It is still knowledge, but a knowledge that is inseparable *even in principle* from the technological apparatus used to perform it. As Otávio Bueno notice, a scanning probe image is not only object-oriented, it is also *experience-oriented*, 'it is also about what it is like to perceive DNA (…) from the perspective of an atomic force microscope' ([13]: 134). Yes, experience-oriented indeed, but not necessarily *human*-experience-oriented. The subject of experiment is as much the AFM cantilever than the DNA; or better, it is the way they in4teract

Nanoscientists are definitely more interested in the singular way by which a singular object interacts with the instrumental tool than in the universal laws that classically define an object *qua* object of science. An STM image of an iron atom is not an instantiation of a general class of atoms: it is a relief of an object situated in a particular environment, according to a certain interaction (Coulomb force, magnetic force, electronic tunnelling, etc.) at the surface of the object, with particular imaging settings, or produced *as* this surface; it is a particular surface of interaction and control, or a surface of affordance, a surface affording definite modes of interaction, or affording an 'object-image', enacted in-between. In probe microscopy, the image enacts and witnesses a tight communication between scales that is already a possible action on the object (even before the discovery of the STM's ability to manipulate single atoms). This is why I use the term '*imaginaction*' coined by Stiegler to refer to this regime of images.[16]

[16] The *concept* of 'imaginaction' has surfaced in the course of a common work with Bernard Stiegler and Xavier Guchet, during a three-year seminar on nanotechnology hosted by the Institute of Research and Innovation at the Centre Pompidou of Paris (http://www.iri.centrepompidou.fr/evenement/nano_technologies/). But the *term* 'imaginaction' is Stiegler's [64]. He coined it in a workshop we co-organized on 'hyperminiaturization' by referring to what I was calling 'imagotechnology'. I was using this latter term in two ways: 1) in a narrow sense, to denote the

2. Transmodality

2.1. Touching things

The primacy of touch over sight has been emphasized by many probe microscopists [8, 27]. In addition to probe microscopy, there are other elements that allow asserting the primacy of touch in the nano-realm: optical or magnetic tweezers used to grab proteins and measure the forces of molecular motors [14]; nanotribology, the science of textures and friction at the nanoscale [6]; and molecular recognition, a mutual 'prehension' [69] that the chemist Jean-Marie Lehn describes as molecules processing information by touching each other [41].

For sure, sight is the privileged sense of reference for the epistemologies of representation, for which objectivity is often conceived as 'blind sight' ([18]: 17) and scientific image as the product of 'mind's eye' ([18]: 86, 168). Sight is supposedly the sense of distance whereas touch is the one of immediateness and pure contact—which is not entirely true: touch calls to *tact*, that is the insertion of a minimal distance in a situation of promiscuity, potential violence and lack of distinction[17]. Whatever it may be, focusing on the 'epistemology of the finger'—as some focus on the 'epistemology of the eye' [18]—would be restricting our analysis to the phenomenological part of nano-images only. Instead, it may be more fitting to emphasize the *transmodal* character of these images themselves. Transmodality, here, means capturing what is given in one perceptive modality to express it into another: from sight to touch, from touch to audition, etc. Or, like Deleuze commenting on Bacon's painting put it, 'how to paint sound, or even a scream? And conversely, how to make colors audible?' ([21]: 57).

If 'transmodality' is a suitable concept for characterizing the logic of the sensible performed by nano-images, it can then account for the alleged primacy of

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apparatuses that do not produce images of a distant object but that include the object's operation in their production so that the manipulation of the object and the production of an image are one and the same process. Imagotechnology refers to the production of what I have called elsewhere '*image-objects*'. 2) In a broader and seemingly more metaphoric sense, 'imagotechnology' refers to new ways of 'imagining matter' or to a 'technology of imagination' that is shaping the aesthetic mode into which our relationship with materiality is framed. However it is not purely metaphoric because it entails a particular 'schematism'—a Kantian concept that will be made use of and explicated below—which is technologically constructed and enacted, and which imposes a certain configuration to the relations between sensory modalities (visibility, tangibility, audibility…) as well as to the relations between the percept or logic of the sensible and the concept or logic of sense. One way to differentiate between the two concepts might be to say that 'imagotechnology' designates the material setup that produces an 'imaginaction'. But I want to avoid referring the former to the object (or to 'imaging') and the later to the subject (or to 'imagining'), as what interests me instead is the interweaving of the technical and the conceptual. For that reason, 'imaginaction' can more aptly be construed as a partial, disparate and dynamic conjunction of 1) and 2).

[17] As Derrida [24] recalls, many taboos are expressed as a principle of 'don't touch!'…or rather, 'do not touch too much'—a half-permissive taboo underlining the need to insert the minimal distance of *tact* in the relation between the feeler and the felt; and a reversible relation since touch is also where what phenomenology calls 'self-affection' first stems: one is always 'touching-touched' before becoming 'seeing-visible' and 'hearing-oneself-speak'. Touching can be caressing as well as hitting. In order to allow the emergence of awareness of the world and of the others, touch has to be measured.

touch: indeed, more than any other sense, touch has a transmodal character. For Jean-Luc Nancy ([49]: 17) 'touch is nothing other than the touch of sense altogether and of all the senses. It is their sensuality as such'. By touch, all the senses are substitutable to each other. Touch is where all senses impinge on each other… touch each other. This explains, Nancy remarks, why there is no genre of art specifically dedicated to touch. Following Nancy, Derrida [24] undertakes to show that behind the apparent privilege of sight in philosophy as the sense of distance and contemplation lays an old haptocentric tradition that awards privilege to touch precisely in order to dispute the legitimacy of any hierarchies between the senses. But let's go back to nanotech images themselves.

2.2. Images beyond vision

Scanning a piece of mica with an AFM, you obtain these very nice pictures (Fig. 8). But the raw data is not the picture itself: it is the curve below, expressing how the AFM 'feels' the mica in terms of variations of amplitude versus frequency of its cantilever's vibrations during lateral scans. The picture is just a visual display obtained by a digital 'collage' of all the lateral curves of scanning.

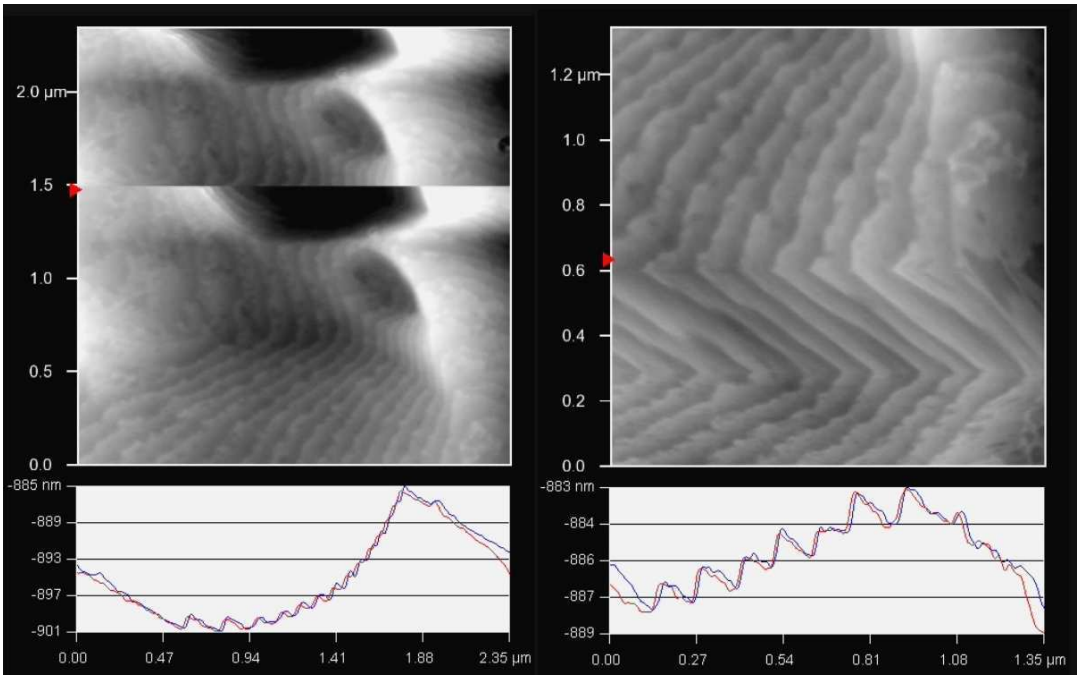

Fig. 8 Listening to the stones: Fast scanning of hydrofluoric acid-etched mica by AFM. Retrieved May 14, 2011 from http://www.asylumresearch.com/Gallery/Movies/Movie15.shtml

But who says that you have to set the system to deliver visual depictions? You can use a haptic interface that will send a force feedback to your hand, which enables you to touch or to scratch the mica as the tip's apex of the cantilever does. You can use sound as well, turning your AFM into a kind of phonograph, and listen to the mica.

Using the AFM to listen to cells has been reported by Gimzewski and co-workers [28]—a practice that they have labelled 'sonocytology'. It notably allowed them to study the differentiations of cancer cells from healthy cells during the evolution of a tumour. The method has also led to a collaboration with the media artist Victoria Vesna for the exhibition *Cell Ghosts* at Seoul in 2004. The installation, where images of the visitor are captured, projected in particles' images, and reappearing later as ghosts, also includes ambient sounds composed of data obtained by manipulating living cells [67]. We can thus hear how a cell is 'singing' when it is gently brushed by the AFM, then manipulated, then subjected to chemical or temperature changes, and finally, succumbs to the deadly touch of the AFM[18] (which recalls the connection between touch and *violence* in its most straightforward form). Of course, cells do not sing, but they undergo specific changes in their wall's vibrations which could be rendered with sound better than with images to provide a real-time account of the rate of molecular events inside the cell.

By means of this process, we understand that displaying probe microscopy data in sound is neither more nor less 'artificial' than making images from spectrums' lines—and therein that the meaning of such images is not reducible to the depiction of their visual display, or to any of the features that are displayed in only one determined sensorial modality (audition, touch, etc.). Nano-images are not primarily visual or haptic or audible, etc. They are essentially transmodal.

2.3. Transmodality Across Scales

Transmodality is certainly not specific to the nanoscale. At our scale, a lot of things can of course equally be seen, touched, tasted, heard, and smelled—but this is *multimodality*, not transmodality. Transmodality is nothing paranormal, although we usually do not notice it. It is experienced in everyday life when one is reading aloud a written text, executing a musical partition or visualising musical tones and frequencies. Transmodality relies on the use of media, whose operations are often a matter of translating a sensory modality into another or at another scale.

Nevertheless, at our scale, the transmodal character of percepts induced by media technologies is much of the time obscured. The way we usually refer to things is mostly constrained by vision, perhaps because it allows pointing at things from a distance ('look at this!'). Moreover, the assignment of sensorial qualities (e.g. the redness) to sensorial modalities (e.g. the sight) is therein mostly monomodal. We do not know intuitively how the sound of the redness sounds like. If perceiving the same object through different modalities (i.e. multimodality) goes without saying, shifting from one modality to another does not. Yet our machines allow for it: These are indeed the transducers of everyday life, from tape heads to loudspeakers, to piezoelectric crystals (an essential component of the STM too), to antennas, to television's cathode ray tubes, etc.

[18] To listening cells 'singing' go to http://www.darksideofcell.info/composition.html

Accordingly, the pertinent difference is not between monomodality at our scale and transmodality at the nanoscale. It is rather that transmodality is less constrained by monomodality at the nanoscale: it shows itself unbounded, in its 'free state'. It can thereafter be captured, transduced and displayed into a multiplicity of perceptual modalities with apparatuses such as probe microscopes.

Note that I am not claiming that transmodal percepts are real whereas monomodal perceptions would be mere illusion. Instead, I entirely follow Whitehead in his rejection of the 'bifurcation of nature' between primary and secondary qualities, when he writes that 'the red glow of the sunset should be as much part of nature as are the molecules and electric waves by which men of science would explain the phenomenon. It is for natural philosophy to analyse how these various elements of nature are connected' ([70]: II). At our scale, transmodal percepts are between monomodal percepts, and require machines to be experienced, operated and made thinkable. At the nanoscale, transmodality is the rule rather than the exception, as there are only inorganic and machine-like percepts at the bottom.

2.4. Schematism

If transmodality is the rule rather that the exception in the nano-realm, it necessary goes with technological procedures governing the way transmodal percepts are displayed into determined perceptive modalities. This set of operations can be referred to 'schematism' in the sense of the Kantian philosophy of knowledge—though in a way that Kant would never have agreed with, since it is not about a 'hidden art in the depths of the human soul' ([38]: 181), but about a hidden art in the depths of the technical apparatuses of nanotechnologies.

According to Kant, schematisation is the procedure of imagination allowing to sensibilize the conceptual and conceptualize the sensible. It is that which allows one to draw a mathematical figure (a triangle) or to manipulate symbols (e.g., to make an addition) and, conversely, to recognise a concept (a triangle) into a sensible intuition. A scheme is both a procedure of construction and a procedure of recognition. To Kant, any scheme has to be an abstract procedure, not a concrete image. For if Kantian schematism is performed by imagination, the faculty of producing and reproducing images, it is only under the jurisdiction of understanding, the faculty of abstract concepts.

If nanotechnologies entail a schematism, it functions in a different way. Unlike Kant's, it is less a mediation between the sensible and the conceptual (with imagination bridging the two), than a mediation between the sensible and the sensible, mediated by the computational. It can be putted by the following sequence, highlighted by the semiologist Patrick Pajon [52]:

'Detect-Compute-Display'

An example can be provided by relating the way probe microscopists recognise a peculiar specimen, here a 'molecular wheelbarrow' (Fig. 9).

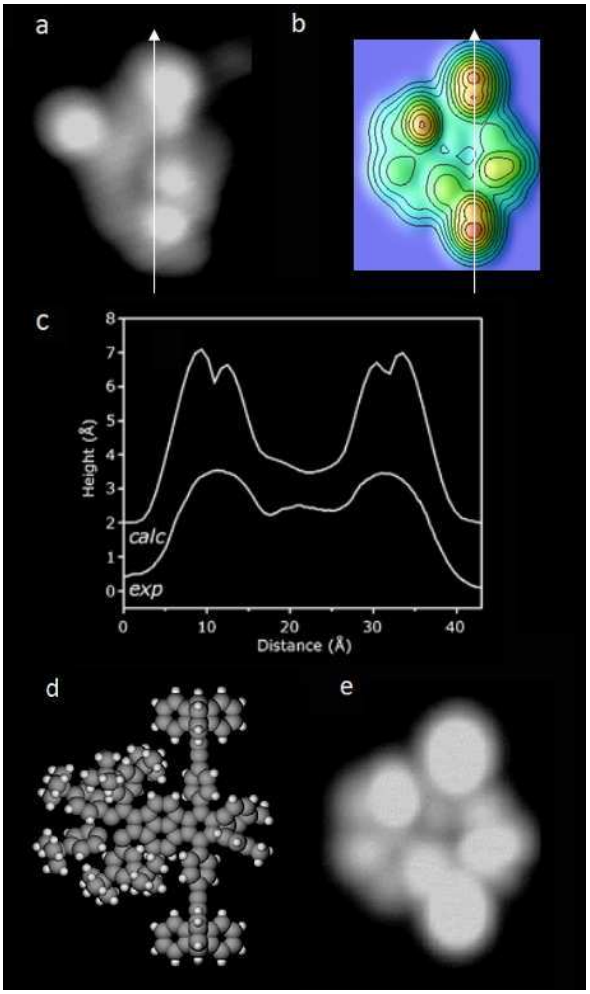

Fig. 9 Detecting-computing-displaying a molecular wheelbarrow: **a** Experimental STM image ('blind image'); **b** 'calculated image'; **c** comparison of experimental and calculated height profiles along the 'wheel' axis; **d** 'visual-friendly image' (Molecular Mechanics chemical model); **e** 'anticipated image'. Source: Nano-science Group at CEMES-CNRS, Toulouse, France.

Figure 9a is a numerical collage of Δ-height curves of a molecule adsorbed on a surface. STMers name this image the 'experimental image'. It is an image obtained by detection, a 'blind' image. This first image is then computed into quantitative data by means of a program devised in the lab. The software uses several theories (quantum conductance through an organic molecule and theoretical chemistry) and semi-empiric methods of approximation to compute the experimental image according to other data (molecular orbitals coordinates, interaction potentials of the surface, and imaging conditions). It allows for the generation of a 'calculated image' (figure 9b). Then, the experimental and the calculated image are compared (see the two Δ-height curves on figure 9c). Sometimes, this comparison is done by the mediation of a so-called 'anticipated image' that shows how the experimental image would look like according to parameters that are well-defined by the theory.[19] If they are assumed to be matching, the calculated image will finally be displayed in a 'visual-friendly' way

[19] It is this image that Bueno [13] calls 'theoretical image'.

(here: a Molecular Mechanics chemical model, figure 9d) allowing one to 'visualize' the interpretation (here: the conformation taken by the 'molecular wheelbarrow' when adsorbed on the surface). As we saw it, the calculated image can also possibly be displayed in a haptic or a sonorous modality. And it is also possible to look or listen to the experimental picture directly, but it would be—and most of the time, it is—hard to interpret. The cognitive interpretation of the image ('what do we see?' 'What do we hear?') is generally occurring at the level of the calculated image, because it is the level where the image gives grasp to the theory (not immediately, but by the mediation of some associated softwares to produce 'anticipated images'). All this is a very mediated and complicated process. The reason for this may be that, paradoxically, the price to pay for the shrinking of distance is a renouncement to the 'artful constructions of immediacy' [50].

What is first detected by scanning probe apparatuses are neither 'primary qualities' (intelligible features that exist 'in themselves' independently of any perceiver), nor 'secondary qualities' (pure subjective impressions that exist only 'for us'). It is a kind of nonhuman sensitivity enabled by devices whose operation is to put different scales and different sensorial modalities in communication.

3. A New Sensible Condition

If one can talk about haptic or auditive as well as visual images, and if nano-images are essentially transmodal, on what ground are we to assert that a trans-modal percept is still an image, even before being seen, heard, or touched, that is, transduced into an image-sound, an image-touch, image-vision, etc.? If there are only machine-like percepts at the bottom, are we still talking about the sensible? And what does it mean to perceive like a machine? Does it even mean something?

Of course, these puzzling questions matter as far as one is willing to go be-yond the bare fact that these nano-images are given on a paper print or on a computer screen, and ask what it means for our sensible condition that they do exist in the first place.

3.1. Perception into Things and Images in Themselves

These difficulties can be addressed by reading the philosophical half a fiction staged by Bergson in the first chapter of *Matter and Memory* [7]. In order to investigate the relationship between matter and perception, he proposes a thought experiment where one substitutes the perception impregnated with our past with a perception 'confined to the present and absorbed, to the exclusion of all else, in the task of moulding itself upon the external object' ([7]: 24), a 'pure perception', 'impersonal', deprived of any memory and withdrawn from all individual contingencies. He warns the reader that one never encounters such a 'pure perception', since our lived present is always mingled with memories and oriented towards our possible actions. From our actual perceptions, 'we then retain only a few hints, thus using them merely as "signs" that recall to us former images' ([7]: 24). Nevertheless, Bergson seeks to show that 'the individual accidents are merely

grafted on to this impersonal perception, which is at the very root of our knowledge of things' ([7]: 25). Once memory is withdrawn, perception therefore appears not as a shadow above things, not as a mental photography,[20] not as a representation, but as an operation *occurring into things*. Perception is neither a picture in our mind ('Idealism', referred by Bergson to Berkeley), nor a secondary quality which does not look like what it represents ('Realism', referred to the 'mechanical philosophers' of the 17th century). Who indeed believes, like the idealist, says Bergson that things might disappear when I do not perceive them? Who believes, like the realist, that the real table is distinct from the perceived table? The thought experiment allows Bergson to claim that there is no difference of *kind* between perception and matter, but only a difference of *degree*, whereas there is a difference of kind between perception and memory,[21] the latter constituting the individuated side of our apprehension of things. There is no other choice, he then argues, than to posit that the world is composed of images that exist 'in themselves' and not 'in us', even without being perceived.[22] These images do not disappear once the perceiver is gone. They are less than what the realist calls a 'thing' and more than what the idealist calls a 'representation'. They are physical interactions existing in themselves, each one constantly acting and reacting with all other images according to all the laws of nature (whether known or unknown).

> 'By positing the material world we assume an aggregate of images, and moreover because it is impossible to assume anything else. (…) Reduce matter to atoms in motion (…) Condense atoms into centres of force, dissolve them into vortices revolving in a continuous fluid (…): they are still images. It is true that an image may be without being perceived; it may be present without being represented; and the distance between these two terms, presence and representation, seems just to measure the interval between matter itself and our conscious perception of matter' ([7]: 26–27).

What happens then between 'presence' and 'representation'? In other words, if for images there is merely a difference of degree, and not of kind, between being and being consciously perceived, then what does the perception of the image add to the image? Actually, in the perceived image, there is *less*, and not more, than in matter: Perception results therefore from a selection of images and not from the addition of a representational dimension. Here is the trick: Bergson

[20] 'The photography, if photography there be, is already taken, already developed in the very heart of things and at all the points of space' ([7]: 31).
[21] Which is directed controversially against classical empiricism (Hume, Berkeley, etc.), for which a memory is only a sensation of less intensity.
[22] Simondon's Imagination et invention [63] walks in the footsteps of Bergson's non-representational account of images: images do exist even before being perceived; they partake to a cycle that begins before us. But whereas Bergson insists on actual perception as a subtraction, a cut into the plane of images, Simondon insists on invention as an antidote to proliferation: images require our potentials of artistic or technical invention in order to be guided into existence, along the lines of a common world. Otherwise, they may formautonomous worlds that catch people like dreams do. To Simondon, invention is image-driven, but it also seems to be a way to expel images out of ourselves.

assumes some images to be slightly different than others in that they insert some *duration* between their stimuli and their reaction on other images and that they can react sometimes differently to the same stimulus, whereas all the others interact in a fully deterministic and quasi-instantaneous way. These are 'living bodies', also termed 'centres of indetermination'. This is the only assumption Bergson makes: the existence of indetermination in some nodes of the universe (i.e. freedom in the weakest sense possible). These images do not perceive other images by representing, but by acting: 'I call *matter* the aggregate of images, and *perception of matter* these same images referred to the eventual action of one particular image, my body' ([7]: 8). This latter image-body is disturbing and tuning the field of interaction of the others in function of its possible action: The image-body acts on and reacts to a second image; and as part of its action it responds to some features of the second image while not registering others. Our perception is then the measure of our possible action: it results from the discarding of what has no interest for our needs and our functions. Once perceived, the images are still the same, only minus the qualities that are irrelevant to the perceiver's action. Amongst all equally real scales of reality, what a perceiving agent does is to select a particular 'frequency' to interact with some images at the scale where it needs to act, just as probe microscopes or other nano-sensor/actuator devices do. Perception is function of the scale where one undertakes to act.

Deprived of memories and without interiority, Bergson's 'subject' of pure perception is really an 'imaginactor' more than a producer of representations. It acts on images and amidst images. Moreover, Bergson's paradoxical appeal to commonsense philosophy in the midst of philosophical fiction relating a situation that no one can ever encounter as such, bears undoubtedly some analogy with nanotechnology's affordance of the familiar and the picturesque in the midst of the unfamiliar. Scanning probe images are some kinds of 'images in themselves' that decentre us from our anthropocentric vantage points of perception and action. Whether Bergson is right or wrong,[23] the breach he has opened up (and promptly shut down) in the representational philosophy of perception might be the one where nanotechnologies plunge us, with the restriction perhaps that the 'centres of perception and indetermination' are no longer limited to living bodies but extend to inorganic ones as well—thereby rather an enlargement than a restriction of Bergson's account of perception.

3.2. Interobjectivity

In a number of nanotech manipulations, an electron, a photon, a spin, an atom, a molecule, a surface, a nanoparticle, etc…, are not only of interest as objects of study bearing interesting properties, but also as potential detectors, sensors, probes, actuators, that is to say all that can interact with an entity/object/process at the scale where it acts on other entities/objects/processes. This well instantiates

[23] For he himself distinguishes the thought experiment of pure and instantaneous perception from the 'concrete and complex perception—that which is enlarged by memories and always offers a certain breadth of duration' (Bergson [7]: 26). He will then retrace his steps to correct what he himself declares to be 'excessive' by bringing memory back in again.

Whitehead's idea that all interrelations between 'actual entities' should be ontologically considered as much real and valuable than the relations between those that are classically considered as subjects versus objects [69]. Interobjective relations matter.

Moreover, the way this interobjectivity matters do transform our relationship with materiality. In the regime of representation, the subject of knowledge elevates himself *above* the sensible by placing his instruments between representation and matter. The knower's relation to the matter of knowledge is placed under the sign of *verticality*. In the regime of imaginaction, our relation with materiality becomes *horizontal* as well. And so becomes the very notion of *control*, omnipresent in the grand narratives of nanotechnology as well as in the scientific literature: Control would no longer refer to the sole affirmation of man's power over matter, restricted to the situation of dumb objects in the hands of smart engineers. It would rather refer to the instauration of robust relationships of co-prehension between nanoscale objects/entities/process, horizontally, and to a knowledge gained by partaking in these mutual prehensions. It is it this sense that in nanotechnology, control is not the proof of knowledge, but knowledge itself, operative knowledge, technological knowledge [43]—which does not mean *full* knowledge or *full* control in the sense of vertical control; it rather implies a quite *local* and self-limited knowledge, as it can only be complete regarding the parameters taken under consideration for locally achieving a particular performance in a certain milieu. However this does not prevent this technological knowledge to look for generic schemes allowing 'delocalizing' a phenomenon from one kind of environment to another: from low temporature to room temperature, from vacuum to air, from liquid-phase to surface, from conducting surfaces to insulating ones, etc [51].

With this notion of interobjectivity, everything happens as if we would be gaining some access to the way objects/entities/processes have access to each other—to the sensible life of non-living things. Is such thinking more than a *vue de l'esprit*? One might object that only a sentient subject can be called 'sensitive'. If this would be the case, these horizontal relationships—let's say for instance, between a molecule functionalized to 'sense' some feature of the surface where it is adsorbed, and a STM tip functionalized to 'probe' this 'sensitivity' itself—should be referred to as mathematical series instead of anthropomorphic images alluring to sensitive objects. The two poles of representation—the 'purely human' view, and the 'view from nowhere'—would thus be restored, and everything would be back into order. We could indeed do so, but then we would miss the meaning of such an experimentation. Moreover, the claim that an object is sensitive to another object implies no anthropomorphism, for is not about 'projecting' human sensitivity onto other types of sensitivity. If in the contrary we consider seriously such a claim, then we are also to consider that the aesthetic question of nanotechnology is not only the question of how it changes *our* sensible condition and *our* being-in-the-world, but also how it changes the sensible condition and being-in-the-world *of objects*—expressions unacceptable for many philosophers, for which an object is only the correlate of a subject, the sole sensitive pole.

3.3. Inorganic Sensibility

The logic of the sensible deployed by nanotechnologies is no more a phenomenological one, grounded on the relation of man-and-the-world, and this is precisely why a techno-aesthetic approach is needed. For many phenomenological philosophies, the so-called 'nanoworld' would probably not be a world at all since there is no room in it for the inscription of the lived body and thus, no being-in-the-world. There is no flesh at the bottom.[24]

As Deleuze and Guattari put it when they dare the phenomenological concept of 'flesh' to constitute the *being* of the sensible and not just the 'thermometer' involved in revealing it ([22]: 178–179),

> 'This ground, this rhythmic unity if the senses, can be discovered only by going beyond the organism. The phenomenological hypothesis is perhaps insufficient because it merely invokes the lived body (…), a paltry thing in comparison with a more profound and almost unlivable Power [puissance]. We can seek the unity of rhythm only at the point where rhythm itself plunges into chaos, into the night, at the point where the differences of level are perpetually and violently mixed' ([21]: 44).

To Deleuze and Guattari, these processes are neither sensible nor straightforwardly thinkable by themselves even if they might be encountered when one gets trapped in what they name a 'Drug assemblage': 'a perceptive line of causality that makes it so that (1) the imperceptible is perceived; (2) perception is molecular; (3) desire directly invests the perception and the perceived' ([23]: 311). To allow molecular processes to be experienced out of a 'Drug assemblage' without falling into the abyss, one needs to get equipped with adequate instrumentation and sophistically elaborated materials.

So do nanotechnologies. Against transhumanists, it can be stressed that nanotechnologies are not exactly 'enhancing' the biological makeup—and herein the sensory performances—of the human. Instead, they strive to render livable and habitable for humans, the unlivable *inorganic* depths of the sensible. They afford experimental access to a sensible that is not reducible to the modalities of the (post-/trans-/super-)human access to it. Like Deleuze's account of the operations of art as a matter of 'capturing forces' [21], the operations of nanotechnologies are a matter of taking advantage of, playing with, amplifying and filtering, the various sorts of processes (electronic, electrostatic, repulsive /attractive van der Waals, magnetic, optic, plasmonic, etc.) by which nano-objects act, are acted upon, and interact. As suggested by the 'molecule-Ampere-meter' (Fig. 6) and the 'manipulated atom image' (Fig 7) experiments, the 'rendering sensible' process takes place both 'vertically' (between subjects and objects) and 'horizontaly' (between objects). To put it like Whitehead, it is about prehending nano-entities in a way analogous to the way they prehend each other [69]—a way

[24] The late Merleau-Ponty grants flesh to be 'the Sensible in itself, this anonymity innate to Myself' (Merleau-Ponty [46]: 139), 'the formative medium of the object and the subject' (Merleau-Ponty [46]: 147).

to access the way nano-objects access their environment. As Nathan Brown [12] contends, nanotechnologies are challenging less the differences between physical, living, and human beings than they are challenging their respective access to the world and world-forming powers. Especially, they challenge the Heideggerian tripartition between the 'worldless' character of the physical thing (the stone), the 'poor in world' character of the living being (the lizard on the stone), and the 'world-forming' character of *Dasein* (man). For Brown, the world-forming power termed by Heidegger 'the open' is now attributable to inorganic objects as well, for they display an inorganic sensibility to which we can partly access. Nanotechnologies question the very confinement of the category of the 'sensible' in subject-object correlations where only the subjective pole of the correlation is to be world-forming and sensible. In nanotechnologies, the object is no more a mere correlate of the subject (*Gegenstand*) in a representation; it becomes, as Brown put it, 'nothing-otherthan-object'.[25] The 'nothing-otherthan-object' means both the mode of existence of the physical being as 'not without access' to itself and the world, and a threshold condition of 'openness-towards' that might pass through and between any being (non-living, living, human), and that humans can experiment or even become when ceasing to maintain representational relationships with objects.

While we are becoming sensible to atoms, it is not only *our* sensible condition that is affected but also the one *of objects*. Yet, thereafter, we are to comprehend our own sensibility differently, by highlighting the inorganic part of it. Indeed, if we are able to desire being the lizard basking in the sun, just as much can we desire being the stone heated by sunlight. We do not need to project ourselves into the inorganic realm to make such a sensibility thinkable. It just has to arise to us. 'It's the same story for music, says Deleuze, when it elaborates a sonorous material to render audible those forces that are not audible in themselves. In music, it's no longer a matter of an absolute ear but rather an impossible ear that can alight on someone, arise briefly in someone' [19].

4. Conclusions

What if the foremost transformative power of nanotechnologies is neither scientific nor industrial, but rather aesthetical? This essay has engaged the aesthetical question of nanotech as *a question concerning the sensible*. Nanotechnologies can be characterized by the *arising of a new sensible* beyond representation. Or, using the Deleuzian triad of the concept, the percept, and the affect [22], we could say that we and the atoms are now forming a different per-

[25] Following Graham Harman's 'object-oriented philosophy' [34, 35], Brown's 'nothing-otherthan-object' also challenges another Heideggerian dichotomy: between 'thing' and 'object'. Heidegger was indeed praising the former—the jug or the old bridge [36]—as unveiling the ontological structure of the world and disqualifying the former as expressing modern science's and metaphysics' will to subject the world to categories of representation (substance/properties, matter/form, etc.). Nano-objects overcome this dichotomy: a nanomachine for example, is a technical object, but also a thing, since its mode of existence is not exhaustible to a conceptual set of representations inherent to a specific corpus of science [30].

cept/concept/affect nexus. Concept: imaginaction rather than representation. Percept: transmodal rather than unimodal or multimodal. Affect: inorganic rather than bio-centered.

Unlike particle physics or astrophysics, nanotechnologies they do not produce visible representations of invisible things. They are rather attempting at turning an unlivable and transmodal 'chaosmos' into a habitable 'life-world' where we would be able to discern and to act on things in using our usual perceptive modalities—a crazy challenge, since there is no flesh at the bottom. The problem is not therefore the displacement of the divide between the visible and the invisible, it is rather the way this divide is altered from within, 'enacted in between' ([3]: 359) and reconfigured in terms of inhabiting, in an attempt to bring familiarity within the unfamiliar. Each nanotech realization transforms space by inhabiting the kind of milieu where it succeeds [51], and it succeeds in a process that Simondon calls 'concretization' [43, 61], that is, by turning some of the constraints of its environment into an 'associated milieu', by determining which constraints matter and how, by *making sense* of its environment.

If, as their promoters claim, nanotechnologies really are to revolutionize our everyday life regarding the technologies we use and live with, then I argue that this potential is not to be found in the endless list of incredibly useful applications that nanotechnologies promise to deliver, but in the way they techno-aesthetically transform both our sensible condition and the sensible condition of objects. Nanotechnologies are not only a new way of rendering invisible objects sensible *to humans*, but a new way of construing the *being* of the sensible—not only as a sensibility *to* atoms (epistemological), but also as a sensibility *of* atoms (ontological). Objects are no more mere correlates of a subject as in the relation of representation, where the subject is the only sensible pole. Nanotechnologies render thinkable and afford experimental access to a sensible that is infinitely deeper than the modalities of its human access. Though ways of construing the sensible without resorting to the mirror games of representation has been explored by certain philosophies—as the ones referred to above—, it has never constituted the usual business of a world-wide technology. Here we are now.

Techno-aesthetics may help us to address issues regarding the social use of nanotechnologies in terms of schematisation of transmodality, especially regarding future devices that would integrate sensory-motor access to nanoscale processes. Who indeed will choose the perceptive modality in which such or such image-process will interfere with the gestures of use? Which kind of common space is to arise if it relies on a previous delimitation of perceptive modalities?

Such issues could be addressed in terms of 'distribution of the sensible', according to the term of Jacques Rancière, who refers to 'the system of self-evident facts of sense perception that simultaneously discloses the existence of something in common and the delimitations that define the respective parts and positions within it' (Rancière [55]: 12). Indeed, by framing the modes of perception and enunciation of a common nano-space with delimitations between what is visible and invisible, tangible or intangible, sayable and unsayable, audible and inaudible, the nano-engineered perceptive spaces also tend towards distributing the roles: who will be granted the competences to determine which features of the nano-

space should be rendered sensible and who will be authorized to talk about it? These are social and political questions.

If a techno-aesthetic approach is one that dares to posit and articulate sensibility beyond the privileged sphere of subject/object relationships, it engages us simultaneously to consider the political nature of our responsibilities towards the design of nano-engineered perceptive spaces. If nanotechnologies cannot succeed but by inhabiting and bringing some familiarity within the unfamiliar, the iconic strategies they use—as it is all about images—might also turn out to be counter-productive, inappropriate and aesthetically impoverishing. Depicting atoms, molecules and surfaces as familiar and picturesque objects situated in a space that stands ready to be colonised, conceals the collapse of representation and maintains instead a poor relationship of adherence to the visual—a relationship to which nanotechnologies themselves can help us to get free of. Depicting the nanoworld as if it was merely 'ours' is a manner of undermining the mode of existence of its inhabitants, a way of withdrawing from our relationship with nanotech the significance of interobjective relationships, and finally, a way to repress the mutation of the sensible described here by attempting to contain it in a parody of representation. Yet when asked about 'artists depictions' they are fond of, very often, researchers answer that 'it is just a representation', i.e., the phenomena depicted are idealized, etc. But precisely these images are not representations since they are using the same likeness and familiarity that has always been perceived as a threat against due representations, that which should be maintained at distance by both the epistemology and the apparatuses of representation. As Marc Pavlopoulos put it [53], these images are not lying because they do not represent what they aim at, but because they seem to pretend that they are representations. However, calling for a new detachment with regard to the aesthetic power of nano-images would be the worst strategy to endorse, as it would be the best way to let this small world function unbeknownst to us and reconfiguring our 'life-world' without us.

This is where I believe that the practices of *artists* and art *critics* might play a decisive role, a role that scientific practices of nanotech are perhaps not able to play. Indeed, what can be captured in the artistic realizations concerned by nanotechnology are the ways in which possible 'distributions of the sensible' can be set up, given to experiment, and undone; the way in which a certain practice of transmodality can go against the instantaneous harnessing of attention by the visual and the use of screens in order to lengthen and deepen perception, populate the interstices, 'making strange' [16, 59]. The valuable contribution of artists should not be restricted to the operation of 'rendering the invisible visible'—as it is often claim about nano-art—; instead, it should also seek to *rendering intelligible the way things are rendered sensible*, or else, *making strange the way things are rendered familiar*. Artists—or rather, their productions—are also there to remind nano-facturers that, despite their grand ambitions regarding the design of our common 'life-world'… they might turn out to be bad artists.

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